1999

AERODYNAMIC FAIRING DEVELOPMENT FOR CALIOPE

Richard M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Sandia National Laboratories

OBJECTIVE: To design and test a prototype aerodynamic fairing for a telescope to be mounted on the Altus unmanned aerial vehicle in order to minimize airflow disturbances and maintain optimum optical quality.

SUMMARY: A candidate fairing was designed by a multi-agency design team. A half-scale wind tunnel model was constructed and tested in the NPS 3.5- by 5-foot low-speed wind tunnel. The model was instrumented with 125 pressure ports, and pressure surveys were conducted at various angles of attack and sideslip resulting in contour pressure plots and estimated total window loads. Finally, a pressure survey was made along the midline of the top hatch of the forward-fuselage model for the determination of cooling inlets and exhausts.

UAV MARINIZATION STUDY

Richard M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: CNO-N88 and the Naval Postgraduate School (NIFR)

OBJECTIVE: To work with investigators at the Center for Naval Analyses to study the feasibility of a marinized Medium Altitude Endurance (MAE) Unmanned Aerial Vehicle (UAV).

SUMMARY: A comparison was made of the various technologies supporting a possible ship-based UAV for maritime reconnaissance. Studied were performance evaluations, engine development, launch and recovery, cost estimation, survivability, and other pertinent concerns.

SSAT TECHNOLOGY ASSESSMENT AND RISK REDUCTION STUDY

Richard M. Howard, Associate Professor
Garth V. Hobson, Associate Professor
Ramesh Kolar, Adjunct Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center, Weapons Division

OBJECTIVE: To develop an interactive model in the form of a computer program to allow for the assessment of current and predicted technologies pertaining to subscale subsonic aerial targets (SSATs) leading to the direction of technology development and risk reduction strategies for the realization of a joint subscale aerial target (JSAT).

SUMMARY: A report was written describing the governing equations and relations for the purpose of analyzing the performance and cost of various potential aerial targets from the viewpoints of airframe performance, engine performance, and airframe structure. An interactive computer program, SATUP (Subscale Aerial Target Utility Program), was produced in MATLAB® for use by the tri-services for analysis of desired targets based on the BQM-34 and the MQM-107.

1998

DEPLOYMENT OF THE APEX AIRCRAFT AT HIGH ALTITUDE

Richard M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: NASA Dryden Flight Research Center

OBJECTIVE: To assist a design team in the development of a remotely-piloted aircraft to be dropped from 100,000 feet for aerodynamic experimentation.

SUMMARY: The meteorological need for atmospheric data at high altitudes requires basic data for the design of efficient aircraft able to loiter for extended periods in this extreme environment. The Apex program is producing a high-altitude testbed aircraft to achieve trimmed flight at altitudes of over 100,000 feet to conduct aerodynamic experiments. The work this year continued the development of a 1/3-scale radio-controlled sailplane with its associated airborne sensor and data acquisition system (ASDAS). This is a continuing project.

UAV MARINIZATION

Richard M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: NAVAIR

OBJECTIVE: To determine the charcteristics of a UAV optimized for launch and recovery at sea. To delineate applicable technologies which currently exist to field a maritime UAV and, if lacking, what technologies are required and when they will be expected to mature.

SUMMARY: A review of UAV technologies relevant to a maritime UAV was conducted, with particular attention paid to the VTOL configuration. This effort was a combined project with the Center for Naval Analyses, who provided the lead effort. The work is continuing.

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UNMANNED AIR VEHICLE TECHNOLOGY DEVELOPMENT

R.M. Howard, Associate Professor; R.P. Shreeve, Professor,
G.V. Hobson, Associate Professor
Department of aeronautics and Astronautics
Sponsor: Defense Airborne Reconnaissance Office

OBJECTIVE: To support future UAV development with studies of the potential performance of alternate engines for application in Predator and Global Hawk classes of UAV's, of bus architectures for a common UAV architecture, and of improved airframe aerodynamics through modeling and simulation.

SUMMARY: A panel computer program was used to model the Predator Unmanned Aerial Vehicle at its trim flight condition. An analysis was begun to study how future external modifications might impact range and endurance. In avionics, a proof-of-concept cell-phone architecture was developed as a COTS approach to a common bus architecture for future UAVs. In propulsion, reconnaissance missions require relatively low power and/or high altitudes. Current reciprocating engines do not have the reliability of gas turbines and can not use heavy fuel. Analytical studies examined the potential impact of gas turbine engine variants on reconnaissance vehicles with emphasis on the recuperated gas turbine cycle. An experimental study sought to establish performance characteristics of small gas turbines operating with JP fuel. This is a continuing program.

1996

DEPLOYMENT OF THE APEX AIRCRAFT AT HIGH ALTITUDE
Richard M. Howard, Associate Professor
Sponsor: NASA

OBJECTIVE: The meteorological need for atmospheric data at high altitude requires basic aerodynamic data for the design of efficient aircraft able to loiter for extended periods in this extreme environment. The APEX High Altitude Flight Experiment Program is producing a high-altitude testbed aircraft to achieve trimmed flight at altitudes near 100,000 feet to conduct aerodynamic experiments. The proposed launch technique using a balloon lift, vertical drop, and remotely-piloted recovery demands further study to determine the optimum flight profile to achieve flight goals and prevent loss of aircraft. This project is continuing in FY97.

SUMMARY: Six-degree-of-freedom simulation studies were performed to achieve various design points throughout the flight profile, based on chord Reynolds number, Mach number, and lift coefficient. Parameters varied during the studies included release altitude and angle of attack during pullout. Output variables considered included the design conditions as well as descent rates and total time aloft for power budget and system design considerations.

1995

A COMPARISON OF FLIGHT INPUT TECHNIQUES FOR PARAMETER ESTIMATION OF HIGHLY-AUGMENTED AIRCRAFT

R.M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: NASA

OBJECTIVE: The objective of this project was to improve the estimation of aerodynamics parameters at high angles of attack by comparing the responses from various classical and modern optimal flight inputs through the use of uncertainty analysis in a parameter-estimation method.

SUMMARY: Recent techniques have been devised for the optimal design of flight inputs for the estimation of stability-and-control derivatives for aircraft at high angles of attack. It was desired to perform a comparison of the results from the new optimal techniques with those of more traditional sequential single-surface inputs. Two optimal input techniques, a single-surface input (SSI) technique using an onboard excitation system, and the classical doublet technique were flown on the F-18 HARV aircraft at the NASA Dryden Flight Research Center. A widely-used parameter-estimation method, pEst, was used for the data analysis and to predict estimations of the Cramer-Rao bounds for each method. The Cramer-Rao bounds provide an estimate of the expected error of the predicted aerodynamic derivatives. It was found that the automated SSI technique provided the smallest Cramer-Rao bounds, and that deflecting each control surface separately significantly decreased the undesirable correlation between the input control surfaces.

1994

STRAKE AND WING BLOWING FOR VORTEX FLOW CONTROL ON A CROPPED DOUBLE-DELTA CONFIGURATION

R.M. Howard, Associate Professor
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to perform a the application of wing-and-strake blowing for vortex flow control over highly-swept surfaces. Measured were the parameters of lift and drag. This project is part of an ongoing study of enhanced high-angle-of-attack aerodynamics.

SUMMARY: The maintenance of air superiority in the future will depend on maneuvering into the post-stall flight regime, requiring enhanced lift at high angles of attack. Enhanced lift often depends on the formation of strong vortices generated from aircraft strake and wing leading edges, which lift can be compromised by vortex breakdown. Recent studies have used flow-visualization techniques to observe flowfield changes due to pneumatic blowing over wings and strakes, but direct measurements of lift and drag are lacking. Various blowing-port locations, port sweep angles, port inclination angles and blowing coefficients were treated. A maximum lift enhancement of 9 percent was found for blowing port 1 located near the strake apex, at a tube sweep angle of 60 degrees and inclination angle of 0 degrees, at an aircraft angle of attack of 20 degrees. Up to the maximum blowing coefficient of 0.022, lift increased linearly with blowing coefficient. If the linear trends continue at higher blowing coefficients (achievable by other investigators), lift increase of from 12 to 25 percent may be possible.

AIR-MOBILE GROUND SECURITY SYSTEM PLATFORM ASSESSMENT

R.M. Howard, Associate Professor
I.I. Kaminer, Assistant Professor
Sponsor: Naval Command, Control and Ocean Surveillance Center

OBJECTIVE: The goal of this project was to assist the sponsor in this evaluation of advanced-technology unmanned air vehicles under contract. In particular, NPS expertise was needed in the areas of vehicle performance, stability and control, guidance and navigation, and communications. This is an ongoing project.

SUMMARY: The Naval Command, Control and Ocean Surveillance Center, RDT&E Division (NRaD), solicited advanced development technology proposals to support the Air-Mobile Ground Security System Program. The mission of the program is to enhance the effectiveness of rear-area physical security and force protection through extended range surveillance, area intrusion detection, assessment and identification. The air-mobile platform has demanding requirements, such as vertical takeoff and landing (VTOL), ducted-fan propulsion, and autonomous operations.

First, evaluations were made of the various proposals submitted of an air vehicle designed to perform the mission. From the inputs of the Principal Investigators and members on the NRaD staff, awards were made to three contractors. On-site demonstrations followed, with field tests of the various air vehicles, Input from the Principal Investigators was received in the way of oral and written reports. An important issue of concern was the sensor suite necessary to carry out the required mission. A study was performed of optimal blending of INS (Inertial Navigation System) and GPS (Global Positioning System) information. The project is expected to continue as the program moves into Phase II.

DEVELOPMENT OF A TRAINING AID FOR AIRCRAFT FLYING IN CLOSE PROXIMITY

R.M. Howard, Associate Professor

Sponsor: Naval Air Systems Command

OBJECTIVE: The goal of this project was to conduct a computer analysis of the aerodynamic interference between dissimilar aircraft flying in close formation, and to produce a training video from the computer graphics to educate fleet aviators in the hazards of formation flying.

SUMMARY: During an in-flight emergency such as an unsafe landing-gear indication, a second aircraft may be sent aloft for a visual inspection. The inherent danger involved with aircraft flying in close proximity, especially aircraft very dissimilar in size and wing loading, may not be sufficiently stressed during flight safety training. A numerical study of the aerodynamic interference between an F-14 and a T-34 aircraft flying in close formation was conducted. Two cases were treated: one with the T-34 closing vertically on the F-14 from beneath, and the second with the T-34 closing horizontally on the F-14 in a step-down position. Graphical output consisted of plotted streamlines, pitching moments, reduced lift, elevator angle to trim, and color plots of surface pressures on the T-34 wing and tail. It was found that a strong nose-up pitching moment resulted from the downwash from the larger lead aircraft. This pitching moment was coupled with a reduction in lift due to the trailing aircraft's location on the pressure side of the lead aircraft. As a result, the pilot would have the sensation of a nose-up pitching tendency while being "pushed away" – conflicting cues for the pilot as the aircraft close to within a wingspan distance. An understanding of the aerodynamic interference and the expected lift and trim changes by trained fleet aviators should help to avoid the possibility of a collision.

DEVELOPMENT OF A VTOL UNMANNED AIR VEHICLE FOR TRANSITIONAL FLIGHT

R.M. Howard, Associate Professor
I.I. Kaminer, Assistant Professor
Sponsor: Naval Air Systems Command

OBJECTIVE: The goal of this project was to develop a vertical-takeoff-and-landing Unmanned Air Vehicle (UAV) as a technology demonstrator for the VTOL mission. The effort included airframe design and construction, modeling, simulation, sensor and datalink integration, and testing. This is an ongoing effort.

SUMMARY: The current inventory of UAVs lacks a suitable platform able to meet the increased need for real-time intelligence in fleet operations from small surface combatants. Limited shipboard assets and launch-and-recovery capabilities call for systems small and more readily deployable than current systems. A candidate for the VTOL mission must not only takeoff and land vertically, but also transition to horizontal flight for a high dash speed and efficient loiter capability. Assets from two cancelled programs were combined to provide a novel airframe concept for the vehicle. The Archytas air vehicle is a tailsitter design, with a ducted-fan propulsion system for efficiency and safety, and with wings and a canard tail surface for horizontal flight. The wing spars joining the wings to the airframe were designed, tested, and fabricated. Prior to making the attachment, thrust and torque tests were completed with the ducted-fan unit. A spread-spectrum datalink system was designed and tested on the fixed-wing testbed, for later use on the Archytas. A non-linear six-degree-of-freedom (6-DOF) motion model, along with sensor and actuator models, were developed and tested with an aerodynamic model of the hovering air vehicle. A Kalman filter was developed to integrate Differential GPS (DGPS) and an Inertial Measurement Unit (IMU) for autoland applications. A robust Multi-Input Multi-Output (MIMO) controller was designed for the Archytas and tested in hardware-in-the-loop simulation. Continued work is leading to hover tests and the pitch-over maneuver.

1993

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SUMMARY: That current inventory of UAVs lacks a suitable platform able to meet the increased need for real-time intelligence in fleet operations from small surface combatants. Limited shipboard assets and launch-and-recovery capabilities call for systems small and more readily deployable than current systems. A candidate for the VTOL mission must not only takeoff and land vertically, but also transition to horizontal flight for a high dash speed and efficient loiter capability. Assets from two cancelled programs were combined to provide a novel airframe concept for the vehicle. The Archytas air vehicle is a tailsitter design, with a ducted-fan propulsion system for efficiency and safety, and with wings and a canard tail surface for horizontal flight. The wing spars jointing the wings to the airframe were designed, tested, and fabricated. Prior to making the attachment, thrust and torque tests were completed with the ducted-fan unit. A spread-spectrum datalink system was designed and tested on the fixed-wing testbed, for later use on the Archytas. A non-linear six-degree-of-freedom (6-DOF) motion model, along with sensor and actuator models, were developed and tested with an aerodynamic model of the hovering air vehicle. A Kalman filter was developed to integrate Differential GPS (DGPS) and an Inertial Measurement Unit (IMU) for autoland applications. A robust Multi-Input Multi-Output (MIMO) controller was designed for the Archytas and tested in hardware-in-the-loop simulation. Continued work is leading to hover tests and the pitch-over maneuver.

1992

CANARD/WING INTERACTION FOR ENHANCED LIFT IN AIRCRAFT SUPERMANEUVERABILITY
R.M. Howard, Associate Professor
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to define the vortex-interaction flow mechanism for a close-coupled-canard aircraft configuration by flowfield measurements in downstream crossplanes. The measurements determined local velocity magnitudes and flow pitch and yaw angles, as well as contours of loss in total pressure.

SUMMARY: The maintenance of air superiority in the future will depend an ability to perform high-lift maneuvers, often into the post-stall flight regime. Canards located in close proximity to swept wings are known to provide increased lift due to the canard and wing leading-edge vortices. Studies of flowfield measurements at the angles of attack for which major lift enhancements are found have been lacking. Wake surveys at an angle of attack of 22 degrees were conducted at three crossplanes to produce plots of crossplane velocity vectors and contours of total pressure. The canard vortex clearly provided the mechanism for massive flow reattachment over the inboard wing section.

Flow visualization indicated the previously-separated flow over the wing became a strong coherent leading-edge vortex under the influence of the canard vortex.

ADVANCED DEVELOPMENT RESEARCH PROGRAM FOR JOINT-SERVICE UNMANNED AIR VEHICLES
R.M. Howard, Associate Professor
Sponsor: Unfunded

OBJECTIVE: The goal of this project is to develop technologies applicable to the new class of Unmanned Air Vehicles: Maritime, Close-Range, and Vertical Takeoff and Landing (VTOL).

SUMMARY: Current launch-and-recovery techniques of UAVs at sea are inadequate for future systems, which will operate from small surface combatants. Air vehicles will be required to takeoff and land vertically, to provide an adequate amount of deck safety from whirling blades, and to transit at speeds of fixed-wing platforms. The design, construction and testing of a full-scale VTOL UAV was begun this past year, using available assets from cancelled DoD programs. The UAV is a tailsitter configuration, taking off vertically and transitioning to forward flight through a pushover maneuver. This year, progress was made in the design and construction of the spar structure to mount wings to the ducted-fan platform, and in testing of control-vane effectiveness using a newly-constructed torque/thrust stand.

APPLICATION OF H_∞ AND MIXED H_∞ TWO/H_∞ SYNTHESIS TO THE DESIGN OF ROBUST TRACKING CONTROLLERS AND RELATED THEORY

I.I. Kaminer, Assistant Professor

Sponsor: AA Department
Funding: Naval Postgraduate School

OBJECTIVE: To investigate the application of H_∞ and mixed H_∞ two/H_∞ synthesis techniques to the design of robust tracking controllers. Furthermore, should there be a lack of theoretical tools needed to accomplish this task, such tools will be developed.

SUMMARY: In the work covered by this proposal we would like to address certain issues which are important for the design of control systems for air vehicles. In particular, we propose to apply recently developed robust control design methodologies to a number of real-life control design problems. For the case of nonlinear plants such designs are usually done for linear models of the plant around a number of nominal operating conditions. It turns out that for a certain class of nonlinear plants such designs result in gain-scheduled controllers. The issue of properly implementing such controllers has received little attention in the literature. Therefore, we propose to develop a methodology to properly implement gain-scheduled controllers on the nonlinear plants.

ADVANCED AVIONICS TECHNOLOGY

I.I. Kaminer, Assistant Professor

Sponsor: Naval Air Command AAS&T
Funding: Naval Air Command AAS&T

OBJECTIVE: To perform research and development in advanced avionics technology topics.

SUMMARY: In the work covered by this proposal we would like to address certain issues which are important for design of avionics systems for air vehicles. In particular, we propose to investigate the applicability of sensor and actuator failure detection and isolation techniques (FDI) developed for automobile electronic systems to aircraft avionics systems. Next, we propose to develop differential GPS/INS navigation system f or aircraft avionics autoland systems. Finally, in order to facilitate proper development and testing of the above systems we propose to build the real-time hardware-in-the-loop simulation station with the 3D animation capability.